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# DECLARATION

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[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION]

OPTICAL RECORDING MEDIUM AND OPTICAL RECORDING METHOD

[CLAIMS]

[Claim 1] An optical recording medium comprising a light transmission layer constituting a light incidence plane, a substrate constituting an opposite surface of the optical recording medium to the light transmission layer and a plurality of information recording layers disposed between the light transmission layer and the substrate and capable of recording data in the plurality of information recording layers and reproducing data recorded in the plurality of information recording layers by projecting a laser beam via the light transmission layer onto the plurality of information recording layers, a recording film contained in at least one information recording layer other than a farthest information recording layer from the light transmission layer among the plurality of information recording layers comprising a plurality of inorganic reaction films.

[Claim 2] An optical recording medium in accordance with Claim 1, wherein the plurality of inorganic reaction films comprises a first inorganic reaction film containing Cu as a primary component and a second inorganic reaction film containing Si as a primary component.

[Claim 3] An optical recording medium in accordance with Claim 2, wherein the first inorganic reaction film is added with at least one element selected from a group consisting of Al, Zn, Sn, Mg and Au.

[Claim 4] An optical recording medium in accordance with Claim 2 or 3, wherein a difference in light transmittances between a case where the first inorganic reaction film and the second inorganic reaction film are laminated and a case where the first inorganic reaction film and the second inorganic reaction film are mixed is equal to or smaller than 4 %.

[Claim 5] An optical recording medium comprising a light transmission layer constituting a light incidence plane, a substrate constituting an opposite surface to the light transmission layer and a plurality of information recording layers disposed between the light transmission layer and the substrate and capable of forming a recording mark in a recording film contained in each of the information recording layers by projecting a laser beam via the light transmission layer onto the plurality of information recording layers, a difference in light transmittances between a region of the recording film contained in at least one information recording layer other than a farthest information recording layer from the light transmission layer among the plurality of information recording layers where a recording mark is formed and a blank region thereof is equal to or smaller than 4 %.

[Claim 6] An optical recording method comprising a step of projecting a laser beam onto an optical recording medium comprising a light transmission layer constituting a light incidence plane, a substrate constituting an opposite surface to the light transmission layer and a plurality of information recording layers disposed between the light transmission layer, a recording film contained in at least one information recording layer other than a farthest information recording layer from the light transmission layer among the plurality of information recording

layers comprising a plurality of inorganic reaction films, thereby recording data in and/or reproducing data from each of the plurality of information recording layers.

[Claim 7] An optical recording method in accordance with Claim 6, wherein a wavelength of the laser beam is 200 nm to 450 nm.

## [DETAILED DESCRIPTION OF THE INVENTION]

[0001]

## [FIELD OF THE INVENTION]

The present invention relates to an optical recording medium and an optical recording method and, particularly, to an optical recording medium including a plurality of laminated information recording layers and an optical recording method for recording data in such an optical recording medium.

[0002]

## [DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. Such optical recording media require improvement in ability to record large amounts of data and various proposals have been made in order to increase the data recording capacity thereof. One of these is an optical recording medium having two recording layers and such an optical recording medium has been already put to the practical use as an optical recording medium adapted to enable only data reading, such as the DVD-Video and the DVD-ROM. In such an optical recording medium adapted to enable only data reading, pre-pits formed on the surface of a substrate serves as an information recording layer and such substrates

are laminated via an intermediate layer.

[0003]

Further, an optical recording medium having multiple information recording layers has been recently proposed in connection with optical recording media in which data can be rewritten by the user and Japanese Patent Application Laid Open No. 2001-243655 discloses a data rewritable type optical recording medium including two information recording layers, for example. In the optical recording medium disclosed in Japanese Patent Application Laid Open No. 2001-243655, a phase change type recording film and dielectric films (protective films) sandwiching the phase change type recording film are used as an information recording layer and the information recording layers having such a structure are laminated via an intermediate layer.

[0004]

In the case where data are to be recorded in an optical recording medium including two information recording layers in which data can be rewritten by the user, the phase state of a recording film included in one of the information recording layers is changed by adjusting the focus of a laser beam onto the one of the recording layers, setting the power of the laser beam to a recording power $Pw$ whose level is sufficiently higher than a reproducing power $Pr$ and projecting the laser beam onto the recording layer to form a record mark at a predetermined region of the recording layer. Since the reflection coefficient of the thus formed record mark is different from those of blank regions in which no record mark is formed, it is possible to reproduce data recorded in one of the recording layers by adjusting the focus of the laser beam onto the recording layer, projecting the laser beam whose power is set to the reproducing power $Pr$ and detecting the amount of light reflected by the recording layer.

[0005]

In this manner, in the optical recording medium having two recording layers in which data can be rewritten by the user, since data are recorded in one of the recording layers and data recorded in the recording layer are reproduced by adjusting the focus of the laser beam onto the recording layer and projecting the laser beam onto the recording layer, when data are to be recorded in the farther recording layer (hereinafter referred to as the "L1 layer") from the light incident plane and data are produced therefrom, the laser beam is projected via the closer recording layer (hereinafter referred to as the "L0 layer") to the light incident plane onto the L1 layer.

[0006]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

Therefore, in the case of recording data in the L1 layer which is a lower layer and reproducing data from the L1 layer, since a laser beam is projected onto the L1 layer via the L0 layer which is an upper layer, the amount of a laser beam projected onto the L1 layer and the amount of the laser beam reflected by the L1 layer and detected are influenced by the L0 layer. Accordingly, in the case where the light transmittance of a region of the L0 layer where a record mark is formed and that of a blank region of the L0 layer where no record mark is formed are greatly different from each other, when data are recorded in the L1 layer and data recorded in the L1 layer are reproduced by adjusting the focus of a laser beam on the L1 layer and irradiating the L1 layer with the laser beam, the amount of the laser beam projected onto the L1 layer and the amount of the laser beam reflected by the L1 layer and detected differ greatly depending upon whether the region of the L0 layer through which the laser beam is projected is a region where a record mark is

formed or a blank region. As a result, the recording characteristics of the L1 layer and the amplitude of a signal reproduced from the L1 layer change greatly depending upon whether the region of the L0 layer through which the laser beam is projected is a region where a record mark is formed or a blank region, thereby affecting data recording and data reproduction.

[0007]

In particular, when data recorded in the L1 layer are reproduced, if the region of the L0 layer through which the laser beam is transmitted includes the boundary between a region where a record mark is formed and a blank region, since the distribution of the reflection coefficient is not uniform at the spot of the laser beam, the amount of the laser beam reflected by the L1 layer cannot be accurately detected.

[0008]

Such problems can be solved by decreasing the difference between the light transmittance of a region of the L0 layer where a record mark is formed and that of a blank region of the L0 layer.

[0009]

It is therefore an object of the present invention to provide an optical recording medium which has a plurality of information recording layers and in which data can be written and an optical recoding method for recording data in such an optical recording medium and particularly provide an optical recording medium having a recording film in which a difference between light transmittance of a region thereof where a recording mark is formed and that of a blank region thereof is small and an optical recoding method for recording data in such an optical recording medium.

[0010]

[MEANS FOR SOLVING THE PROBLEMS]

The above object of the present invention can be accomplished by an optical recording medium comprising a light transmission layer constituting a light incidence plane, a substrate constituting an opposite surface of the optical recording medium to the light transmission layer and a plurality of information recording layers disposed between the light transmission layer and the substrate and capable of recording data in the plurality of information recording layers and reproducing data recorded in the plurality of information recording layers by projecting a laser beam via the light transmission layer onto the plurality of information recording layers, a recording film contained in at least one information recording layer other than a farthest information recording layer from the light transmission layer among the plurality of information recording layers comprising a plurality of inorganic reaction films.

[0011]

Since the optical recording medium according to the present invention comprises a recording film including a plurality of inorganic reaction films, it is possible to decrease a difference between light transmittance of a region of the recording film where a recording mark is formed and that of a blank region thereof. Therefore, in the case of recording data in or reproducing data from a lower information recording layer, it is possible to prevent the recording or reproducing characteristics of the lower information recording layer from being influenced by the state of an upper information recording layer.

[0012]

In this case, it is preferable for the plurality of inorganic reaction layers to include a first inorganic reaction film containing Cu as a

primary component and a second inorganic reaction film containing Si as a primary component. In the case where these materials are used, it is possible to decrease the difference in light transmittance with respect to light having a wavelength equal to that of a laser beam used for a next-generation type optical recording medium between a case where these inorganic reaction films are laminated and a case where these inorganic reaction films are mixed up to 4 % or less and it is also possible to reduce load to the environment. Further, it is more preferable for the first inorganic reaction film to be added with at least one element selected from a group consisting of Al, Zn, Sn, Mg and Au. In the case where at least one element selected from a group consisting of Al, Zn, Sn, Mg and Au is added to the first inorganic reaction film, it is possible to suppress a noise level of a reproduced signal lower and improve a long term storage reliability of an optical recording medium.

[0013]

Furthermore, it is more preferable for at least one information recording layer other than an information recording layer farthest from the light incidence plane to include a reflective film containing Ag as a primary component and added with C as an additive. In the case where the at least one information recording layer other than an information recording layer farthest from the light incidence plane includes a reflective film containing Ag as a primary component and added with C as an additive, it is possible to ensure high light transmittance, thermal conductivity and long term storage reliability, while suppressing the increase in cost. Thus, it is possible to simultaneously improve the recording and reproducing characteristics of an information recording layer close to the light incidence plane and those of an information recording layer far from the light incidence plane.

[0014]

The above object of the present invention can be also accomplished by an optical recording medium comprising a light transmission layer constituting a light incidence plane, a substrate constituting an opposite surface to the light transmission layer and a plurality of information recording layers disposed between the light transmission layer and the substrate and capable of forming a recording mark in a recording film contained in each of the information recording layers by projecting a laser beam via the light transmission layer onto the plurality of information recording layers, a difference in light transmittances between a region of the recording film contained in at least one information recording layer other than a farthest information recording layer from the light transmission layer among the plurality of information recording layers where a recording mark is formed and a blank region thereof is equal to or smaller than 4 %.

[0015]

According to the present invention, since the difference in light transmittances between a region of the recording film where a recording mark is formed and a blank region of the recording film is equal to or smaller than 4 %, it is possible to prevent the recording or reproducing characteristics of the lower information recording layer from being influenced by the state of an upper information recording layer.

[0016]

The above object of the present invention can be also accomplished by an optical recording method comprising a step of projecting a laser beam onto an optical recording medium comprising a light transmission layer constituting a light incidence plane, a substrate constituting an opposite surface to the light transmission layer and a

plurality of information recording layers disposed between the light transmission layer, a recording film contained in at least one information recording layer other than a farthest information recording layer from the light transmission layer among the plurality of information recording layers comprising a plurality of inorganic reaction films, thereby recording data in and/or reproducing data from each of the plurality of information recording layers. In this case, it is preferable to use a laser beam having a wavelength of 200 nm to 450 nm.

[0017]

[DESCRIPTION OF THE PREFERRED EMBODIMENT]

Hereinafter, a preferred embodiment of the present invention will now be explained with reference to accompanying drawings.

[0018]

Figure 1 is a schematic cross-sectional view showing the structure of an optical recording medium that is a preferred embodiment of the present invention.

[0019]

As shown in Figure 1, an optical recording medium 10 according to this embodiment includes a disk-like support substrate 11, a transparent intermediate layer 12, a light transmission layer 13, an L0 layer 20 formed between the transparent layer 12 and the light transmission layer 13, and an L1 layer 30 formed between the support substrate 11 and the transparent intermediate layer 12. The L0 layer 20 constitutes an information recording layer close to a light incident plane 13a and is constituted by laminating a reflective film 21, a second dielectric film 22, an L0 recording film 23 and a first dielectric film 24 from the side of the support substrate 11. On the other hand, the L1 layer 30 constitutes a recording layer far from the light incident plane

13a and is constituted by laminating a reflective film 31, a fourth dielectric film 32, an L1 recording film 33 and a third dielectric film 34 from the side of the support substrate 11. In this manner, the optical recording medium 10 according to this embodiment is provided with the two laminated information recording layers, namely, the L0 layer 20 and the L1 layer 30.

[0020]

In the case where data are to be recorded in the L1 layer 30 and data recorded in the L1 layer 30 are to be reproduced, a laser beam L is projected thereon through the L0 layer 20 located closer to the light transmission layer 13. Therefore, it is necessary for the L0 layer 20 to have a high light transmittance. Concretely, the L0 layer 20 has a light transmittance equal to or higher than 30 % with respect to the laser beam L used for recording data and reproducing data and preferably has a light transmittance equal to or higher than 40 %. In order to reduce the diameter of the laser beam L, it is preferable for the laser beam L used for recording data and reproducing data to have a wavelength of 200 nm to 450 nm and a laser beam having a wavelength of about 405 nm is used for a next-generation type optical recording medium currently proposed. In this specification, "A to B where A and B are numeric values having the same unit" means to be equal to or larger than A and equal to or smaller than B.

[0021]

The support substrate 11 serves to ensure mechanical strength required for the optical recording medium 1 and grooves 11a and lands 11b are formed on the surface of the support substrate 11. The grooves 11a and/or lands 11b serve as a guide track for the laser beam L when data are to be recorded in the L1 layer 30 or when data are to be

reproduced from the L1 layer 30. The depth of the groove 11a is not particularly limited and is preferably set to 10 nm to 40 nm and the pitch of the grooves 11a is not particularly limited and is preferably set to 0.2 µm to 0.4 µm. The support substrate 11 has a thickness of about 1.1 mm. The material used to form the support substrate 11 is not particularly limited insofar as the support substrate 11 can support the above described layers. The support substrate 11 can be formed of glass, ceramic, resin or the like. Among these, resin is preferably used for forming the support substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the support substrate 11 include polycarbonate resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin is most preferably used for forming the support substrate 11 from the viewpoint of easy processing and the like. In this embodiment, since the support substrate 11 constitutes a plane of the optical recording medium 10 opposite to the light incidence plane 13a, it is unnecessary for the support substrate 11 to have a light transmittance property.

[0022]

The transparent intermediate layer 12 serves to space the L0 layer 20 and the L1 layer 30 apart by a physically and optically sufficient distance and grooves 12a and lands 12b are alternately formed on the surface of the transparent intermediate layer 12. The grooves 12a and/or lands 12b serve as a guide track for the laser beam L when data are to be recorded in the L0 layer 20 or when data are to be reproduced from the L0 layer 20. The depth of the groove 12a and the pitch of the grooves 12a can be set to be substantially the same as those of the grooves 11a formed

on the surface of the support substrate 11. It is preferable to form the transparent intermediate layer 12 so as to have a thickness of 5 μm to 50 μm and it is more preferable to form it so as to have a thickness of 10 μm to 40 μm. The material for forming the transparent intermediate layer 12 is not particularly limited and an ultraviolet ray curable acrylic resin is preferably used for forming the transparent intermediate layer 12. It is necessary for the transparent intermediate layer 12 to have sufficiently high light transmittance since the laser beam L passes through the transparent intermediate layer 12 when data are to be recorded in the L1 layer 30 and data recorded in the L1 layer 30 are to be reproduced.

[0023]

The light transmission layer 13 serves to transmit the laser beam L and one of the surface thereof constitutes the light incident plane 13a. It is preferable to form the light transmission layer 13 so as to have a thickness of 30 μm to 200 μm. The material for forming the light transmission layer 13 is not particularly limited and, similarly to the transparent intermediate layer 12, an ultraviolet ray curable acrylic resin is preferably used for forming the light transmission layer 13. As described above, since the laser beam L passes through the transparent intermediate layer 13, it is necessary for the light transmission layer 13 to have sufficiently high light transmittance.

[0024]

Next, the respective films constituting the L0 layer 20 and the L1 layer 30 will be described below.

[0025]

In this embodiment, as shown in Figure 2 (a), each of the L0 recording film 23 included in the L0 layer 20 and the L1 recording film 33 included in the L1 layer 30 is formed by laminating an inorganic

reaction film 51 disposed on the side of the support substrate 11 and an inorganic reaction film 52 disposed on the side of the light transmission layer 13. As shown in Figure 2 (a), the inorganic reaction film 51 and the inorganic reaction film 52 are laminated at a region of the L0 recording film 23 or the L1 recording film 33 where data are not recorded. When a laser beam L having a power equal to or larger than a predetermined level is projected onto the L0 recording film 23 or the L1 recording film 33, as shown in Figure 2 (b), an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are partially or entirely mixed with each other by heat generated by the irradiation of the laser beam, thereby forming a recording mark M. As a result, since the reflection coefficient of a mixed region of the recording layer where the recording mark is formed and that of other regions of the recording layer with respect to a laser bream for reproducing data are different from each other, data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in reflection coefficient therebetween.

[0026]

Therefore, in order to obtain a reproduced signal having a high output, it is necessary to select materials as those for forming the inorganic reaction film 51 and the inorganic reaction film 52 so that the difference in the reflection coefficients with respect to light a laser beam used between when the inorganic reaction film 51 and the inorganic reaction film 52 are laminated (Figure 2 (a)) and when the inorganic reaction film 51 and the inorganic reaction film 52 are mixed with each other (Figure 2 (b)). However, in the case where the difference in light transmittances of the L0 recording film 33 between when the inorganic reaction film 51 and the inorganic reaction film 52 are laminated and

when the inorganic reaction film 51 and the inorganic reaction film 52 are mixed with each other is great, the above described problem occurs when data are recording in or data reproduced from the L0 layer 20. Therefore, it s necessary to select, as materials for forming the inorganic reaction film 51 and the inorganic reaction film 52 constituting the L0 recording film 23, materials which have such reflection coefficients with respect to a laser beam used that the difference in them between when the inorganic reaction film 51 and the inorganic reaction film 52 are laminated and when the inorganic reaction film 51 and the inorganic reaction film 52 are mixed with each other is great and have such light transmittances with respect to a laser beam used that the difference in them between when the inorganic reaction film 51 and the inorganic reaction film 52 are laminated and when the inorganic reaction film 51 and the inorganic reaction film 52 are mixed with each other is small. Concretely, in order to record data in or reproduce data from the L1 layer 30 stably, it is preferable to suppress the difference in the light transmittances to be equal to or smaller than 4 % and it is more preferable to suppress the difference in the light transmittances to be equal to or smaller than 2 %.

[0027]

Considering the above requirements, in this embodiment, a material containing one of Cu and Si as a primary component is employed as a material for forming the inorganic reaction film 51 for constituting the L0 recording film 23 and a material containing the other of Cu and Si as a primary component is employed as a material for forming the inorganic reaction film 52. Thus, in the case where a laser beam having a wavelength $\lambda$ of 200 nm to 450 nm is used, the difference in the light transmittances of the L0 recording film 23 between when the

inorganic reaction film 51 and the inorganic reaction film 52 are laminated and when the inorganic reaction film 51 and the inorganic reaction film 52 are mixed with each other can be suppressed to be equal to or smaller than 4 % and it is possible to record data in or reproduce data from the L1 layer 30 stably. In the case where the above described materials are selected, it is possible to make the difference in the light transmittances with respect to a laser beam having a wavelength λ of 405 nm used for a next-generation type optical recording medium to be equal to or smaller than 1 %. Further, each of the inorganic reaction film 51 and the inorganic reaction film 52 contain Cu and Si as a primary component, it is possible to suppress a load to the environment. In this case, it is preferable for the inorganic reaction film 51 to contain Cu as a primary component and for the inorganic reaction film 52 to contain Si as a primary component.

[0028]

Further, it is preferable for the inorganic reaction layer containing Cu as a primary component among the inorganic reaction film 51 and the inorganic reaction film 52 to be added with Al, Zn, Sn, Mg or Au. In the case where Al, Zn, Sn, Mg or Au is added to the inorganic reaction layer containing Cu as a primary component, it is possible to suppress a noise level of a reproduced signal lower and improve a long term storage reliability of the optical recording medium 10. In this specification, the statement that the inorganic reaction film contains a certain element as a primary component means that the content of the element is maximum among the elements contained in the inorganic reaction film.

[0029]

Here, it is unnecessary to consider the difference in light transmittances between before and after data recording when materials

for forming the inorganic reaction film 51 and the inorganic reaction film 52 constituting the L1 recording film 33 are selected but same materials used for forming the L0 recording film 23 may be employed for forming the inorganic reaction film 51 and the inorganic reaction film 52 constituting the L1 recording film 33.

[0030]

Here, since the laser beam L passes through the L0 recording film 23 when data are to be recorded in the L1 layer 30 and data recorded in the L1 layer 30 are to be reproduced, it is necessary for the L0 recording film 23 to have a high light transmittance and it is therefore preferable to form the L0 recording film 23 so as to be thinner than the L1 recording film 33.

[0031]

Concretely, it is preferable to form the L1 recording film 33 so as to have a thickness of 2 nm to 40 nm and form the L0 recording film 23 so as to have a thickness of 2 nm to 15 nm. In the case where the thickness of the L0 recording film 23 or the L1 recording film 33 formed by a laminate body of the inorganic reaction film 51 and 52 is thinner than 2 nm, the change in optical characteristics between before and after irradiation with the laser beam L is small and on the other hand, in the case where the thickness of the L0 recording film 23 exceeds 15 nm, the light transmittance of the L0 layer 20 is lowered and the recording characteristic and the reproducing characteristic of the L1 recording film 33 are degraded. Further, in the case where the thickness of the L1 recording film 33 exceeds 40 nm, the recording sensitivity of the L1 recording film 33 is degraded. Further, it is preferable to define the ratio of the thickness of the inorganic reaction film 51 to the thickness of the inorganic reaction film 52 (thickness of the inorganic reaction film 51 /

thickness of the inorganic reaction film 52) to be from 0.2 to 5.0.

[0032]

Here, it is not absolutely necessary for each of the L0 recording film 23 and the L1 recording film 33 to include the inorganic reaction film 51 and the inorganic reaction film 52 and each of the L0 recording film 23 and the L1 recording film 33 may be constituted by a laminated body including three or more inorganic reaction films insofar as it includes an inorganic reaction film containing Cu as a primary component and an inorganic reaction film containing Si as a primary component and disposed adjacent to the first mentioned inorganic reaction film. For example, each of the L0 recording film 23 and the L1 recording film 33 may be a three-layered structure including two inorganic reaction films each containing Cu as a primary component and a single inorganic reaction film disposed between these inorganic reaction films and containing Si as a primary component. Further, a mixed film formed by mixing a material for forming the inorganic reaction film 51 and a material for forming the inorganic reaction film 52 may be interposed between the inorganic reaction film 51 and the inorganic reaction film 52. Moreover, although the inorganic reaction film 51 and the inorganic reaction film 52 are in contact with each other in the above described optical recording medium 10, anther thin film, for example, a dielectric film, may be interposed between the inorganic reaction film 51 and the inorganic reaction film 52 as occasion demands.

[0033]

On the other hand, the first dielectric film 24 and the second dielectric film 22 formed so as to sandwiching the L0 recording film 23 serve as protective layers for protecting the L0 recording film 23 and the third dielectric film 34 and the fourth dielectric film 32 formed so as to

sandwiching the L1 recording film 33 serve as protective layers for protecting the L1 recording film 33.

[0034]

The thickness of each of the first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth dielectric film 32 is not particularly limited and it preferably has a thickness of 10 nm to 50 nm. In the case where the thickness of each of the first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth dielectric film 32 is thinner than 10 nm, each of the first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth dielectric film 32 does not sufficiently serve as a protective layer. On the other hand, in the case where the thickness of each of the first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth dielectric film 32 exceeds 50 nm, a long time is required for forming it, thereby lowering the productivity of the optical recording medium 10 and there is some risk of cracking the L0 recording film 23 and the L1 recording film 33 due to internal stress.

[0035]

The first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth dielectric film 32 may have a single-layered structure or may have a multi-layered structure including a plurality of dielectric films. For example, if the first dielectric film 24 is constituted by two dielectric films formed of materials having different refractive indexes, light interference effect can be increased. The material for forming the first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth dielectric film 32 is not particularly limited but it is preferable to form the first dielectric film 24, the second dielectric film 22, the third dielectric film 34 and the fourth

dielectric film 32 of oxide, sulfide, nitride of Al, Si, Ce, Ti, Zn, Ta and the like such as $SiO_2$, $Si_3N_4$, $Al_2O_3$, AlN, TaO, ZnS, $CeO_2$ and the like or a combination thereof and it is more preferable for them to contain ZnS・$SiO_2$ as a primary component. Here, ZnS・$SiO_2$ means a mixture of ZnS and $SiO_2$.

[0036]

The reflective film 21 serves to reflect the laser beam L entering the light incident plane 13a so as to emit it from the light incident plane 13a and effectively radiate heat generated in the L0 recording layer 23 by the irradiation with the laser beam L. When data are to be recorded in the L1 recording layer 33 of the L1 layer 30 and data recorded in the L1 recording layer 33 of the L1 layer 30 are to be reproduced, the laser beam L entering the light incident plane 13a impinges onto the L1 layer 30 via the reflective film 21. It is therefore necessary to form the reflective film 21 of a material having a high light transmittance and a high thermal conductivity. Further, it is necessary to form the reflective film 21 of a material having long-term storage reliability.

[0037]

Therefore, it is preferable to employ a material (AgC) containing silver (Ag) as a primary component and added with carbon (C) as an additive for forming a reflective film 21. In the case where the reflective film 21 included in the L0 layer 20 is formed of a material containing Ag as a primary component and C as an additive, it is possible to markedly improve the long-term storage reliability of the reflective film 21 without degrading the inherent high light transmittance and high thermal conductivity of the Ag. Further, material cost is not increased by adding C to the reflective film 21. Therefore, if the reflective film 21 included in the L0 layer 20 is formed of a material containing Ag as a primary

component and C as an additive, a reflective film having a high light transmittance and a high thermal conductivity can be formed and the storage reliability of the optical recording medium 10 can be improved while preventing increase in material cost.

[0038]

Here, it was found that the light transmittance and the thermal conductivity of the reflective film 21 tended to decrease as the amount of C added to the reflective film 21 increased and it was further found that when the amount of C added to the reflective film 21 was equal to or less than a predetermined value, the storage reliability of the optical recording medium 10 was improved as the amount of C added to the reflective film 21 increased and when the amount of C added to the reflective film 21 exceeded the predetermined value, improvement in the storage reliability of the optical recording medium 10 was not remarkable even if the amount of C added to the reflective film 21 was increased. Therefore, it is necessary to determine the amount of C to be added to Ag considering decrease in the light transmittance and the thermal conductivity of the reflective film 21 caused by adding C and the improvement of the storage reliability of the optical recording medium 10.

[0039]

Concretely, when the amount of C added to the reflective film 21 is equal to or less than 5.0 atomic %, it is possible to ensure sufficiently high light transmittance and thermal conductivity of a reflective film for the L0 layer 20 and when the amount of C added to the reflective film 21 is equal to or less than 4.0 atomic %, it is possible to form the reflective film 21 to have a light transmittance close to that of a reflective film 21 formed of pure Ag. Further, when the amount of C added to the reflective

film 21 is equal to or less than 2.5 atomic %, it is possible to form the reflective film 21 having substantially the same light transmittance as that of a reflective film 21 formed of pure Ag. On the other hand, the storage reliability of the optical recording medium 10 is improved when the amount of C added to the reflective film 21 slightly increases. More specifically, in the case where the amount of C added to the reflective film 21 is equal to or less than about 2.0 atomic %, the storage reliability of the optical recording medium 10 is markedly improved as the amount of C added to the reflective film 21 increases and therefore, the storage reliability of the optical recording medium 10 is greatly improved even if the amount of C added to the reflective film 21 is about 0.5 atomic %. However, in the case where the amount of C added to the reflective film 21 exceeds about 2.0 atomic %, improvement in the storage reliability of the optical recording medium 10 is small even if the amount of C is increased.

[0040]

Therefore, it is preferable for the amount of C added to the reflective film 21 to be equal to or less than 5.0 atomic %, more preferable for the amount of C added to the reflective film 21 to be 0.5 atomic % to 5.0 atomic %, further preferable for the amount of C added to the reflective film 21 to be 0.5 atomic % to 4.0 atomic % and particularly for the amount of C added to the reflective film 21 to be about 2.0 atomic %. However, since the actual amount of C added to the reflective film 21 fluctuates within 0.5 atomic % when the reflective film 21 is formed and the improvement in the storage reliability of the optical recording medium 10 is greatly influenced as the amount of C added to the reflective film 21 varies in the case where the amount of C added to the reflective film 21 is equal to or less than about 2.0 atomic %, it is most

preferable for the amount of C added to the reflective film 21 to be about 2.5 atomic %.

[0041]

Since the light transmittance and thermal conductivity of the reflective film 21 included in the L0 layer 20 varies depending upon the amount of C added to the reflective film 21, the thickness of the reflective film 21 is determined based on the amount of C added to the reflective film 21 but, normally, the thickness of the reflective film 21 is preferably thinner than 20 nm and more preferably 5 nm to 15 nm.

[0042]

However, in the present invention, it is not absolutely necessary to form the reflective film 21 of AgC and the reflective film 21 may be formed of a material containing metal having high thermal conductivity such as Ag, Al or the like as a primary component and added with an element useful for improving corrosion resistance such as Au, Cu, Pt, Pd, Sb, Ti, Mg or the like. Further, in the case where a sufficiently high reproduced signal is obtained, the reflective film 21 may be omitted.

[0043]

Furthermore, although not shown in Figure 1, a base protective film may be interposed between the transparent intermediate layer 12 and the reflective film 21. In the case where such a base protective film is interposed, since the reflective film 21 and the transparent intermediate layer 12 are physically spaced, it is possible to prevent the transparent intermediate layer 12 from being damaged by heat when data are recorded in the L0 layer 20. The base protective film can be formed of a material preferably used for forming the first dielectric film 24 or the like and it is preferable to form the base protective film so as to have a thickness of 2 nm to 150 nm.

[0044]

Moreover, although not shown in Figure 1, a transparent heat radiation film made of a material having higher thermal conductivity than that of the material forming the first dielectric film 24 may be interposed between the light transmission layer 13 and the first dielectric film 24. In the case where such a transparent heat radiation film is interposed between the light transmission layer 13 and the first dielectric film 24, heat radiation characteristics of the L0 layer 20 can be further improved. It is preferable to form the transparent heat radiation film so as to have a thickness of 10 nm t0 200 nm. Further, in the case where the transparent heat radiation film is interposed between the light transmission layer 13 and the first dielectric film 24, a dielectric film having a different refractive index from that of the transparent heat radiation film may be further provided between the transparent heat radiation film and the light transmission layer 13. In the case where such a dielectric film is formed, light interference effect can be further increased.

[0045]

The reflective film 31 serves to reflect the laser beam L entering through the light incident plane 13a so as to emit it from the light incident plane 13a and effectively radiate heat generated in the L1 recording film 33 by the irradiation with the laser beam L. The reflective film 31 is preferably formed so as to have a thickness of 20 nm to 200 nm. When the reflective film 31 is thinner than 20 nm, it does not readily radiate heat generated in the L1 recording layer 33. On the other hand, when the reflective film 31 is thicker than 200 nm, the productivity of the optical recording medium 10 is lowered since a long time is required for forming the reflective film 31 and there is a risk of cracking the reflective

film 31 due to internal stress or the like. The material for forming the reflective film 31 is not particularly limited. The reflective film 31 may be formed of the same material as that used for forming the reflective film 21 but unlike the case of forming the reflective film 21, it is unnecessary to consider the light transmittance of the material when a material is selected for forming the reflective film 31.

[0046]

When data recorded in the optical recording medium 10 having above-described configuration are to be reproduced, a laser beam L is projected via the light incidence plane 13a onto the L0 layer 20 or the L1 layer 30 and the amount of the laser beam L reflected by the L0 layer 20 or the L1 layer 30 is detected. Since the light reflection coefficients are different between that of a unmixed region and that of a mixed region (recording mark M) of the L0 recording film 23 or the L1 recording film 33, in the case where a laser beam L is projected onto the L0 recording film 23 or the L1 recording film 33 via the light incidence plane 13a to be focused thereonto, it is possible discriminate whether a region irradiated with the laser beam L is a mixed region or an unmixed region.

[0047]

Here, when data recorded in the L1 layer 30 which a lower layer are to be reproduced, a laser beam L is projected onto the L1 layer 30 via the L0 layer 20 which is un upper layer. However, in this embodiment, since the difference in the light transmittances between a region of the L0 recording film 23 and the blank region thereof is small, the amplitude of a reproduced signal does not greatly change depending upon whether the region of the L0 recording layer 23 through which the laser beam L passes is a region where a record mark is formed or a blank region. Further, when data recorded in the L1 layer 30 are to be reproduced,

even if the region of the L0 recording layer 23 through which the laser beam L passes contains a boundary between a recoded region and an unrecorded region, the distribution of the reflection coefficient can be prevented from becoming extremely nonuniform at the spot of the laser beam L. Therefore, data recorded in the L1 layer 30 can be reproduced in a desired manner. Similarly to the above, in the case where data are to be recorded in the L1 layer 30, data can be recorded in the L1 layer 30 in a desired manner.

[0048]

The optical recording medium 10 according to this embodiment can be fabricated in the following manner.

[0049]

Figures 3 to 6 show the steps of a method for fabricating the optical recording medium 10 according to this embodiment.

[0050]

As shown in Figure 3, the support substrate 11 having grooves 11a and lands 11b on the surface thereof is first fabricated by an injection molding process using a stamper 40. Then, as shown in Figure 4, the reflective film 31, the fourth dielectric film 32, the L1 recording film 33 (the inorganic reaction films 51, 52) and the third dielectric film 34 are sequentially formed on the substantially entire surface of the support substrate 11 on which the grooves 11a and the lands 11b are formed by a gas phase growth process such as a sputtering process, thereby forming the L1 layer 30. The two inorganic reaction layers 51 and 52 constituting the L1 recording film 33 are not mixed immediately after the sputtering process has been completed.

Further, as shown in Figure 5, an ultraviolet ray curable resin is coated on the L1 layer 30 by a spin coating method to form a coating film

and the surface of the coating film is irradiated with an ultraviolet ray via a stamper 41 while it is covered by the stamper 41 and the stamper 41 is removed, thereby forming the transparent intermediate layer 12 formed with grooves 12a and lands 12b on the surface thereof. Then, as shown in Figure 6, the reflective film 21, the second dielectric film 22, the L0 recording film 23 (the inorganic reaction films 51, 52) and the first dielectric film 24 are sequentially formed on substantially the entire surface of the transparent intermediate layer 12 on which the grooves 12a and the lands 12b are formed, by a gas phase growth process such as a sputtering process, thereby forming the L0 layer 20. The two inorganic reaction layers 51 and 52 constituting the L0 recording film 23 are not mixed immediately after the sputtering process has been completed.

[0051]

Then, as shown in Figure 1, an ultraviolet ray curable resin is coated on the L0 layer 20 by a spin coating method to form a coating film and the surface of the coating film is irradiated with an ultraviolet ray, thereby forming the light transmission layer 13. This completes the fabrication of the optical recording medium 10.

[0052]

As described above, digital data can be recorded in the thus fabricated optical recording medium 10 by focusing the laser beam L onto the L0 recording film 23 or the L1 recording film 33 to form a recording mark in a desired manner. Further, after recording data in the L0 recording film 23 and/or the L1 recording film 33 of the optical recording medium 10, digital data recorded in the L0 recording film 23 or the L1 recording film 33 can be reproduced by focusing the laser beam L onto the L0 recording film 23 or the L1 recording film 33 and detecting the amount of the laser beam L reflected from the L0 recording film 23 or the

L1 recording film 33.

[0053]

As described above, in the optical recording medium 10 according to this embodiment, since the L0 recording film 23 included in the L0 layer 20 is constituted by a laminated body of the reaction film containing Cu as a primary component and the reaction film containing Si as a primary component, the difference in the light transmittance between a region of the L0 recording film 23 where a recording mark is formed and a blank region thereof can be suppressed small, while the sufficiently large difference in the reflection coefficients therebetween can be ensured. Therefore, it is possible to record data in and reproduce data from the L1 layer 30 in a desired manner. Further, in the case where Al, Zn, Sn, Mg or Au is added to the reaction film containing Cu as a primary component, it is possible to further lower the noise level of a reproduced signal and improve the long term storage reliability of an optical recording medium.

[0054]

Further, in the case where AgC is employed as a material for forming the reflective film 21, high light transmittance and thermal conductivity and good storage reliability can be ensured while preventing material cost from increasing. In particular, in the case where the amount of C added to Ag contained in the reflective film 21 as a primary component is determined to be equal to or less than 5.0 atomic %, preferably, is determined to be equal to or more than 0.5 atomic % and equal to or less than 5.0 atomic %, more preferably, is determined to be equal to or more than 0.5 atomic % and equal to or less than 4.0 atomic %, most preferably, is equal determined to be to about 2.5 atomic %, extremely high light transmittance and thermal conductivity and better

storage reliability can be ensured. Thus, it is possible to simultaneously improve the recording and reproducing characteristics of the L0 layer 20 and the recording and reproducing characteristics of the L1 layer 30.

[0055]

The present invention has thus been shown and described with reference to a specific embodiment. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0056]

For example, although explanation was made as to an optical recording medium including two information recording layers in the above described preferred embodiment, an optical recording medium to which the present invention is applicable is not limited to the optical recording medium having two information recording layers and the present invention can be applied to an optical recording medium having three or more information recording layers. In this case, it is sufficient for a recording film included any of information recording layers other than an information recording layer farthest from the light incidence plane to be constituted by the laminated body of a reaction film containing Cu as a primary component and a reaction film containing Si as a primary component. However, this does not mean that a recording film included in an information recording layer farthest from the light incidence plane cannot be constituted by the laminated body of a reaction film containing Cu as a primary component and a reaction film containing Si as a primary component but a recording film included in an information recording layer farthest from the light incidence plane may be constituted by the laminated body of a reaction film containing Cu as

a primary component and a reaction film containing Si as a primary component.

[0057]

Further, in the above described preferred embodiment, although each of the L0 layer 20 and the L1 layer 30 includes the recording film constituted by the laminated body of the inorganic reaction films 51, 52, the configuration of the L1 layer 30 is not particularly limited in the present invention and the L1 layer 30 may be constituted an information recording layer adapted to enable only data reading and including no recording layer. In this case, pre-pits are formed on a support substrate and information is recorded by the pre-pits in the L1 layer 30.

[0058]

[WORKING EXAMPLES]

Hereinafter, working examples of the present invention will be set out but the present invention is in no way limited to the working examples.

[0059]

[Preparation of Optical Recording Medium-1]

<u>Working Example 1</u>

An optical recording medium having substantially the same configuration as that of the optical recording medium 10 shown in Figure 1 was fabricated in the following manner.

[0060]

A disk-like polycarbonate substrate 11 having a thickness of 1.1 mm and a diameter of 120 mm and formed with grooves and lands on the surface thereof was first fabricated by an injection molding process so that the track pitch (groove pitch) was equal to 0.32 μm.

[0061]

Then, the polycarbonate substrate 11 was set on a sputtering apparatus and a reflective film 31 consisting of an alloy of Ag, Pd and Cu and having a thickness of 100 nm, a fourth dielectric film 32 containing a mixture of ZnS and $SiO_2$ and having a thickness of 40 nm, an inorganic reaction film 51 containing Cu as a primary component and having a thickness of 3 nm, an inorganic reaction film 52 containing Si as a primary component and having a thickness of 3 nm and a third dielectric film 34 containing the mixture of ZnS and $SiO_2$ and having a thickness of 22 nm were sequentially formed on the surface of the polycarbonate substrate 11 on which the grooves and lands were formed, using the sputtering process, thereby forming an L1 layer 30.

[0062]

Further, the polycarbonate substrate formed with the L1 layer on the surface thereof was set on a spin coating apparatus and acrylic system ultraviolet curable resin is dropped onto the L1 layer while the polycarbonate substrate was being rotated, whereby the L1 layer was spin coated with acrylic system ultraviolet curable resin. Then, a stamper formed with grooves and lands was placed on the surface of the resin layer and the surface of the resin layer was irradiated with an ultraviolet ray via the stamper, thereby curing the acrylic system ultraviolet curable resin. Then, the stamper was removed from the resin layer, whereby a transparent intermediate layer 12 having a thickness of 20 μm and formed with grooves and lands on the surface thereof so that the track pitch (groove pitch) was equal to 0.32 μm was formed by removing the stamper.

[0063]

Then, the polycarbonate substrate formed with the L1 layer and the transparent intermediate layer on the surface thereof was set on the

sputtering apparatus and a reflective film 21 consisting of an alloy of Ag, Pd and Cu and having a thickness of 8 nm, a second dielectric film 22 containing a mixture of ZnS and $SiO_2$ and having a thickness of 28 nm, an inorganic reaction film 51 containing Cu as a primary component and having a thickness of 3 nm, an inorganic reaction film 52 containing Si as a primary component and having a thickness of 3 nm and a first dielectric film 24 containing the mixture of ZnS and $SiO_2$ and having a thickness of 22 nm were sequentially formed on the surface of the transparent intermediate layer using the sputtering process, thereby forming an L0 layer 20.

[0064]

Further, the first dielectric film 24 was coated using the spin coating method with acrylic system ultraviolet curing resin the coating layer was irradiated with ultraviolet rays, thereby forming a light transmission layer having a thickness of 80 μm.

[0065]

Here, the mole ratio of ZnS to $SiO_2$ in the mixture of ZnS and $SiO_2$ contained in the first dielectric layer 24, the second dielectric layer 22, the third dielectric layer 34 and the fourth dielectric layer 32 was 80:20.

[0066]

Thus, the optical recording medium according to Working Example 1 was fabricated.

[0067]

<u>Working Example 2</u>

An optical recording medium according to Working Example 2 was fabricated in the manner of Working Example 1, except that an inorganic reaction layer 51 included in each of an L0 layer 20 and an L1 layer 30 contained Cu as a primary component and added with Al and Au

and was formed so as to have a thickness of 5 nm. The amount of Al added to the inorganic reaction layer 51 was 23 atomic % and the amount of Au added to the inorganic reaction layer 51 was 13 atomic %.

[0068]

<u>Working Example 3</u>

A disk-like polycarbonate substrate 11 having a thickness of 1.1 mm and a diameter of 120 mm and formed with grooves and lands on the surface thereof was first fabricated by an injection molding process so that the track pitch (groove pitch) was equal to 0.32 μm.

[0069]

Then, the polycarbonate substrate 11 was set on a sputtering apparatus and a reflective film 31 consisting of an alloy of Ag, Pd and Cu and having a thickness of 100 nm, a fourth dielectric film 32 containing a mixture of ZnS and $SiO_2$ and having a thickness of 38 nm, an inorganic reaction film 51 containing Cu as a primary component, added with Mg and having a thickness of 5 nm, an inorganic reaction film 52 containing Si as a primary component and having a thickness of 5 nm and a third dielectric film 34 containing the mixture of ZnS and $SiO_2$ and having a thickness of 21 nm were sequentially formed on the surface of the polycarbonate substrate 11 on which the grooves and lands were formed, using the sputtering process, thereby forming an L1 layer 30.

[0070]

Further, the polycarbonate substrate formed with the L1 layer on the surface thereof was set on a spin coating apparatus and acrylic system ultraviolet curable resin is dropped onto the L1 layer while the polycarbonate substrate was being rotated, whereby the L1 layer was spin coated with acrylic system ultraviolet curable resin. Then, a stamper formed with grooves and lands was placed on the surface of the

resin layer and the surface of the resin layer was irradiated with an ultraviolet ray via the stamper, thereby curing the acrylic system ultraviolet curable resin. Then, the stamper was removed from the resin layer, whereby a transparent intermediate layer 12 having a thickness of 20 μm and formed with grooves and lands on the surface thereof so that the track pitch (groove pitch) was equal to 0.32 μm was formed by removing the stamper.

[0071]

Then, the polycarbonate substrate formed with the L1 layer and the transparent intermediate layer on the surface thereof was set on the sputtering apparatus and a reflective film 21 containing Ag as a primary component, added with C and having a thickness of 8 nm, a second dielectric film 22 containing a mixture of ZnS and $SiO_2$ and having a thickness of 32 nm, an inorganic reaction film 51 containing Cu as a primary component, added with Mg and having a thickness of 5 nm, an inorganic reaction film 52 containing Si as a primary component and having a thickness of 5 nm and a first dielectric film 24 containing the mixture of ZnS and $SiO_2$ and having a thickness of 32 nm were sequentially formed on the surface of the transparent intermediate layer using the sputtering process, thereby forming an L0 layer 20. The amount of Mg added to the inorganic reaction film 51 was 21 atomic %.

[0072]

Further, the first dielectric film 24 was coated using the spin coating method with acrylic system ultraviolet curing resin the coating layer was irradiated with ultraviolet rays, thereby forming a light transmission layer having a thickness of 80 μm.

[0073]

Here, the mole ratio of ZnS to $SiO_2$ in the mixture of ZnS and $SiO_2$

contained in the second dielectric layer 22 and the fourth dielectric layer 32 was 80:20.

[0074]

Thus, the optical recording medium according to Working Example 3 was fabricated.

[0075]

[Characteristics Comparison Test 1]

In the Characteristics Comparison Test 1, the amount of a laser beam reflected from the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3 when the laser beam was projected onto the L1 layer via the L0 layer before data were recorded in the L0 layer and the amount of a laser beam reflected from the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3 when the laser beam was projected onto the L1 layer via the L0 layer after data had been recorded in the L0 layer were detected, whereby how the L1 layer was influenced by the L0 layer was studied in the following manner.

[0076]

A laser beam having a wavelength λ of 405 nm was first projected onto the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3 via the L0 layer in which no data were recorded and the amount of the laser beam reflected from the L1 layer was detected, thereby measuring a reflection coefficient R1 of the L1 layer. The laser beam was projected onto the L1 layer using an objective lens having a numerical aperture NA of 0.85. When the laser beam was projected onto the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3, no recording mark was present in the L0 layer within the spot of the laser beam.

[0077]

Then, a random signal including 2T to 8T was recorded in the L0 layer of each of the optical recording media fabricated in Working Examples 1 to 3 in accordance with the 1, 7 Modulation Code.

[0078]

A laser beam having a wavelength of 405 nm was projected onto the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3 via the L0 layer in which the random signal had been recorded and the amount of the laser beam reflected by the L1 layer was detected to measure the reflection coefficient R2 of the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3. When the laser beam was projected onto the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3, the recording marks were uniformly distributed in the L0 layer within the spot of the laser beam.

[0079]

Based on the thus measured reflection coefficients R1 and R2 of the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3, the difference in reflection coefficients ΔR was calculated for the L1 layer of each of the optical recording media fabricated in Working Examples 1 to 3. The results of the measurement and calculation are shown in Table 1.

[0080]

[Table 1]

| | Working Example 1 | Working Example 2 | Working Example 3 |
|---|---|---|---|
| Reflection Coefficient R1 before recording data in L0 layer | 5.7 % | 6.7 % | 6.2 % |
| Reflection Coefficient R2 after recording data in L0 layer | 6.0 % | 6.4 % | 6.0 % |
| Difference in Reflection Coefficients ΔR | 0.3 % | 0.3 % | 0.2 % |

As shown in Table 1, it was found that the difference ΔR between the reflection coefficient R1 of the L1 layer when the laser beam was projected thereonto via the L0 layer in which no data were recorded and the reflection coefficient R2 of the L1 layer when the laser beam was projected thereonto via the L0 layer in which data were recorded was equal to or less than 0.3 % in each of the optical recording media fabricated in Working Examples 1 to 3 and was very small. Thus, it was confirmed that the difference between the light transmittance of a region where a recording mark was formed and the light transmittance of a blank region was very small in the recording film constituted by the laminated body of the inorganic reaction film containing Cu as a primary component and the inorganic reaction film containing Si as a primary component.

[0081]

[Preparation of Optical Recording Medium-2]

A sample having substantially the same configuration as that of the optical recording medium 10 except that the L1 layer 30 and the

transparent intermediate layer were omitted was fabricated in the following manner.

[0082]

A disk-like polycarbonate substrate 11 having a thickness of 1.1 mm and a diameter of 120 mm and formed with grooves and lands on the surface thereof was first fabricated by an injection molding process so that the track pitch (groove pitch) was equal to 0.32 μm.

[0083]

Then, the polycarbonate substrate 11 was set on a sputtering apparatus and a reflective film 21 consisting of an alloy of Ag, Pd and Cu and having a thickness of 8 nm, a second dielectric film 22 containing a mixture of ZnS and $SiO_2$ and having a thickness of 28 nm, an inorganic reaction film 51 containing Cu as a primary component and having a thickness of 5 nm, an inorganic reaction film 52 containing Si as a primary component and having a thickness of 5 nm and a first dielectric film 24 containing the mixture of ZnS and $SiO_2$ and having a thickness of 22 nm were sequentially formed on the surface of the polycarbonate substrate 11 on which the grooves and lands were formed, using the sputtering process.

[0084]

Further, the first dielectric film 24 was coated using the spin coating method with acrylic system ultraviolet curing resin the coating layer was irradiated with ultraviolet rays, thereby forming a light transmission layer having a thickness of 80 μm.

[0085]

Here, the mole ratio of ZnS to $SiO_2$ in the mixture of ZnS and $SiO_2$ contained in the first dielectric layer 24 and the second dielectric layer 22 was 80:20.

[0086]

[Characteristics Comparison Test 2]

In the Characteristics Comparison Test 2, the difference in light transmittances between a case where the two inorganic reaction layers 51, 52 of the above mentioned sample were laminated and a case where the two inorganic reaction layers 51, 52 thereof were mixed with each other was measured by varying the wavelength λ of a laser beam.

[0087]

A laser beam was projected onto the optical recording medium sample and the amount of light transmitted through the optical recording medium sample was measured by varying the wavelength λ within the range of 350 nm to 800 nm, thereby measuring light transmittance of the optical recording medium sample in which the inorganic reaction layers 51, 52 were laminated for each wavelength of the laser beam.

[0088]

Next, a laser beam whose power was set to a high level was projected onto predetermined regions of the two inorganic reaction layers 51, 52, thereby mixing the two inorganic reaction layers 51, 52 within the regions with each other.

[0089]

Then, a laser beam was projected onto the regions and the amount of light transmitted through the optical recording medium sample was measured by varying the wavelength λ within the range of 350 nm to 800 nm, thereby measuring light transmittance of the optical recording medium sample in which the inorganic reaction layers 51, 52 were mixed with each other for each wavelength of the laser beam.

[0090]

Based on the thus measured light transmittances of the optical recording medium sample for each wavelength of the laser beam, the difference ΔT in light transmittances between before and after recording data in the optical recording medium sample was calculated for each wavelength of the laser beam. The results of the calculation are shown in Figure 7.

[0091]

As shown in Figure 7, it was found that when the wavelength λ of the laser beam was within a range of 350 nm to 450 nm, the light transmittance difference ΔT of the optical recording medium sample was equal to or less than 4 % and that when the wavelength λ of the laser beam was within a range of 350 nm to 420 nm, the light transmittance difference ΔT of the optical recording medium sample was equal to or less than 2 %. In particular, it was found that when the wavelength λ of the laser beam was within a range of 350 nm to 410 nm, the light transmittance difference ΔT of the optical recording medium sample was equal to or less than 1 %

[0092]

Thus, it was confirmed that the present invention was particularly effective in the case where a laser beam having a wavelength λ of about 405 nm was employed like a next-generation type optical recording medium.

[0093]

[TECHNICAL ADVANTAGE OF THE INVENTION]

As described above, in the optical recording medium according to the present invention, since the recording film included in an information recording layer close to the light incidence plane is constituted by the laminated body of the inorganic reaction film containing Cu as a primary

component and the laminated body of the inorganic reaction film containing Si as a primary component, it is possible to stably record data in and reproduce data from the lower information recording layer.

## [BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 is a schematic cross-sectional view showing the structure of an optical recording medium 10 that is a preferred embodiment of the present invention.

[Figure 2]

Figure 2 is an enlarged partial cross-sectional view showing an L0 recording film 23 and an L1 recording film wherein Figure 2 (a) shows the L0 recording film 23 and the L1 recording film in which no recording mark is formed and Figure 2 (b) shows the L0 recording film 23 and the L1 recording film in which a recording mark M is formed.

[Figure 3]

Figure 3 is a drawing showing a step of a method for fabricating an optical recording medium 10.

[Figure 4]

Figure 4 is a drawing showing a step of a method for fabricating an optical recording medium 10.

[Figure 5]

Figure 5 is a drawing showing a step of a method for fabricating an optical recording medium 10.

[Figure 6]

Figure 6 is a drawing showing a step of a method for fabricating an optical recording medium 10.

[Figure 7]

Figure 7 is a graph showing how difference ΔT in light transmittances of an optical recording medium sample varied with a wavelength of a laser beam.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

10 ..... an optical recording medium

11 ..... a support substrate

11a, 12a ..... grooves

11b, 12b ..... lands

12 ..... a transparent intermediate layer

13 ..... a light transmission layer

13a ..... a light incidence plane

20 ..... an L0 layer

21 ..... a reflective film

22 ..... a second dielectric film

23 ..... an L0 recording film

24 ..... a first dielectric film

30 ..... an L1 layer

31 ..... a reflective film

32 ..... a fourth dielectric film

33 ..... an L1 recording film

34 ..... a third dielectric film

40, 41 ..... a stamper

51, 52 ..... an inorganic reaction film

**[Name of Document]** ABSTRACT OF THE DISCLOSURE


**[Abstract]**

**[Problems]**

It is an object of the present invention is to provide an optical recording medium in which data can be written and which has a plurality of information recording layers and a recording film whose in which difference in light transmittances between a region where a recording mark is formed and a blank region is small.

**[Solutions]**

An optical recording medium includes a light transmission layer 13 constituting a light incidence plane 13a, a substrate 11 constituting an opposite surface of the optical recording medium to the light transmission layer 13 and an L0 layer 20 and an L1 layer 30 disposed between the light transmission layer 13 and the substrate 11 and is adapted for recording data in and/or reproducing data from the L0 layer 20 and the L1 layer 30, and a recording film 23 included in the L0 layer 20 includes a plurality of inorganic reaction layers 51 and 52. According to the thus constituted optical recording medium, in the case of recording data in or reproducing data from the L1 layer 30, it is possible to prevent the recording characteristics or reproducing characteristics of the L1 layer from greatly changing depending upon the state of the L0 layer 20.

**[Selected Figure]** Figure 1